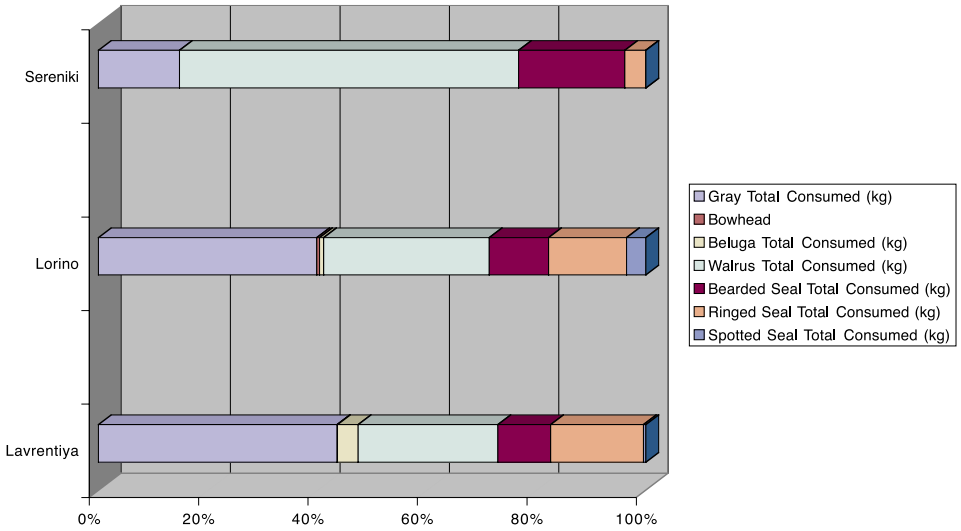


Chart 2. Chukotka: proportion of marine mammals harvested by species.

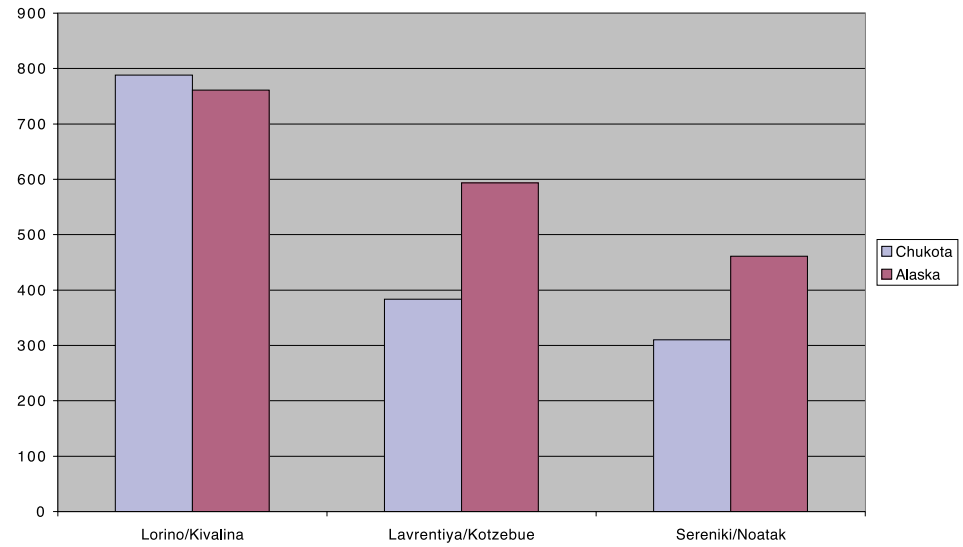


Chart 3. Comparison: Chukotka/NANA Region
Per Capita Consumption of Wildlife Resources in pounds.

income from all sources, food preferences, training and learning about subsistence activities, and estimates of the household's dependence on wildlife resources.

Economic Importance of Wildlife Resources in Traditional Communities

There is certainly no doubt that the harvest of wildlife resources is critical to the diet of indigenous communities on both sides of the Bering Strait. Two simple measures can indicate the level of this importance: per capita consumption of wildlife products and the replacement cost at market value of such resources.

However, one should not be mislead that the economic and dietary impact of subsistence activities is necessarily the most important outcome of these endeavors. Subsistence resources and the activities associated with the harvest of these resources define and establish the sense of family and community. The distribution of these resources establishes and promotes the most basic ethical values in Native and rural culture—generosity, respect for the knowledge and guidance of elders, self-esteem for the successful harvest of a resource, and family and public appreciation in the distribution of the harvest. No other set of activities provides a similar moral foundation for continuity between generations.

Per Capita Consumption of Wildlife Resources

The results confirmed the dependence on marine mammals of the Chukotka study communities. About half to two-thirds of the wildlife resources in the diet of these communities comes from marine mammals. For Lavrentiya, 46% of the per capita harvest of wildlife resources was marine mammals, while Lorino was 68% and Sireniki was 54% *(Chart 1)*. *Chart 2* provides a breakdown by species of community dependence on marine mammals. With the exception of Sireniki, which has limited access to whales but is heavily dependent on walrus, about 40% of all marine mammal consumption comes from gray whales.

Chart 3 indicates the per capita harvest levels of wildlife products for each community. Lorino clearly consumes considerable amounts of wildlife resources, nearly 788 pounds per year (a typical urban American will consume about 220 pounds of meat). This consumption of subsistence resources parallels similar behaviors on the Alaska side of the Bering Strait. Kotzebue (Alaska) is twice the size of Lavrentiya yet both have significant non-Native populations and are regional transportation and service hubs. Lorino is nearly four times the size of the Alaska village of Kivalina, yet both are primarily indigenous communities with strong dependence on marine mammal products. Sireniki and Noatak (Alaska) are about the same size, and both are primarily Native; however, Noatak obtains its primary subsistence diet from land mammals and fish while Sireniki relies primarily on marine mammals.

Household Income

The three Russian study communities in the CSHAP research project demonstrate considerable variance in their circumstances. Lavrentiya has about 60% more income than the other two communities

and 80% of the community's income comes from wage sources. Lorino, with considerably less income, receives about two-thirds of its household income from wage sources. At most risk is Sireniki where nearly 60% of income is derived from welfare, pensions, or similar forms of transfer payments.

Many households and communities in the Alaska Bering Strait region depend heavily on unearned income and seasonal wage work. In general these households have lower incomes and their fortunes have been declining in an era of legislative program cuts. In addition these communities can rarely sustain their low purchasing power under circumstances of even modest inflation.

There is some risk in comparing the economic circumstances of Chukotka communities with those of their counterparts in Alaska. A key difference is that the organization for the harvest and distribution of wildlife resources in Alaska resides with the household or extended family *(Magdanz et al. 2002)*. Although the products of subsistence activities are often widely shared throughout the community, the capital for engaging in subsistence activities is normally borne by the family. Thus, boats, motors, rifles, gasoline, bullets, and all the other expenses are purchased by a household and are used by that household or by close extended family members. In Chukotka few individual households or even extended families have the financial means to support such activities.

With respect to income sources, Bering Strait Alaska communities mirror that of Lavrentiya and Lorino, with about 70% of their income derived from wage sources.

It should be noted that on neither side of the Bering Strait do communities enjoy robust and diversified economies. Most sources of wage income are due to employment in the government or service sector, while most of the construction is linked to federal, state, or regional programs. Neither side, because of a variety of factors including transportation costs, has a viable manufacturing sector. Similar analysis of other economic sectors indicate that all these rural communities on each side of the strait are extremely dependent on transfer payments and programs from federal or "state" (oblast) entities.

Ten years ago most rural indigenous households in Alaska had 15 to 20 times more income than their Chukotka neighbors. However, rural indigenous Alaskans have five to six times less income than non-Native urban dwellers in Alaska whose per capita income at this time is about $26,000. Thus, even if one were to take into account such issues as purchasing power, differences in the provision of health services (now sporadic in Chukotka), and subsidized housing, most observers would agree that the economic conditions of indigenous Chukotka households are considerably more precarious than their counterparts in rural Alaska.

Per Capita Income - 1990 Census*	Kotzebue	Kivalina	Noatak
	$13,906	$4968	$7089
Per Capita Income - 2000 CSHAP	**Lavrentiya**	**Lorino**	**Sireniki**
	$892	$345	$357

Table 1: Three Northwest Alaska Communities and Three Chukotka Communities.
* The latest census for which per capita income is available.

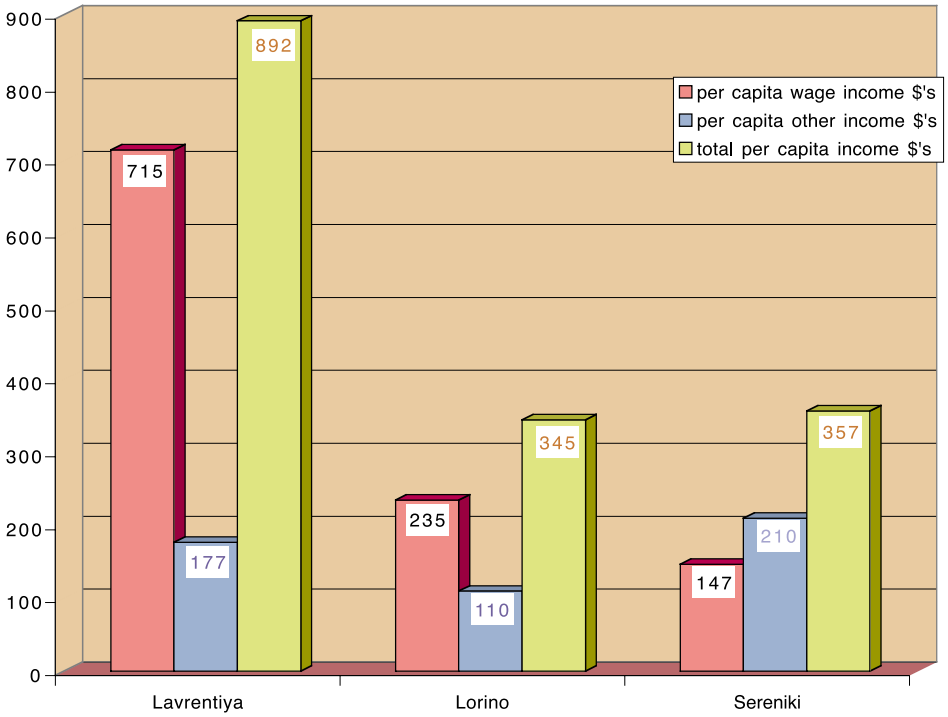


Chart 4. Per capita income in dollars, three Chukotkan communities.

Food and Replacement Costs

Chukotka

The critical nature of modest per capita income is underscored in an examination of household expenditures for food. Of most concern is Sireniki where nearly every available ruble is spent on food. Lorino, despite considerable consumption of wildlife resources, still spends over 60% of its disposable income on food. Finally, Lavrentiya with the highest per capita income spends over half of its total income on food, much of it western foods. Western foods, such as canned goods, bulk grains, potatoes, or a variety of other processed items are usually imported from central Russia.

Alaska

Northwest Alaska communities are substantially dependent on wildlife resources. Statistical data indicate that rural

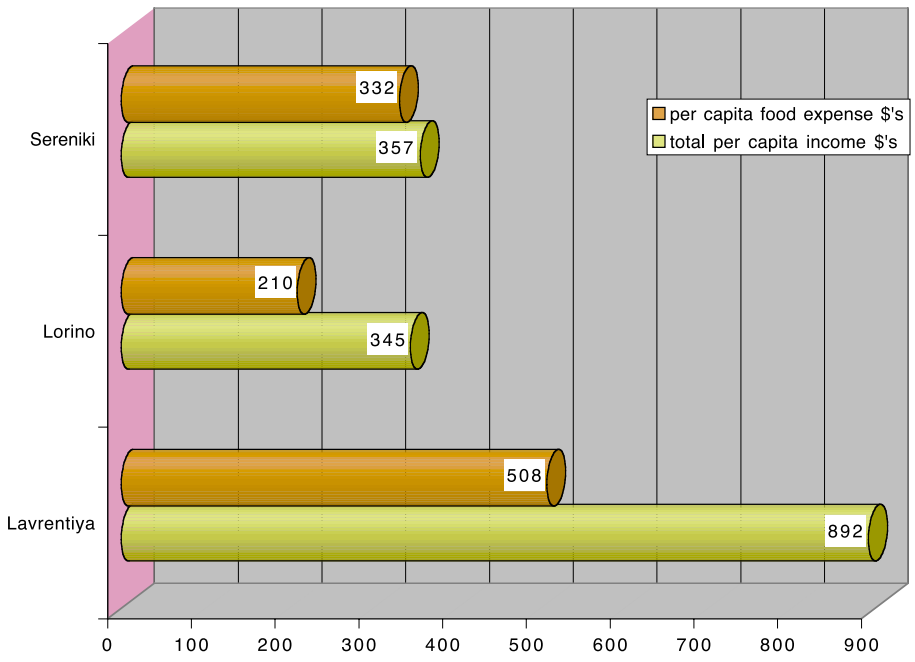


Chart 5. Per capita income and food costs in dollars.

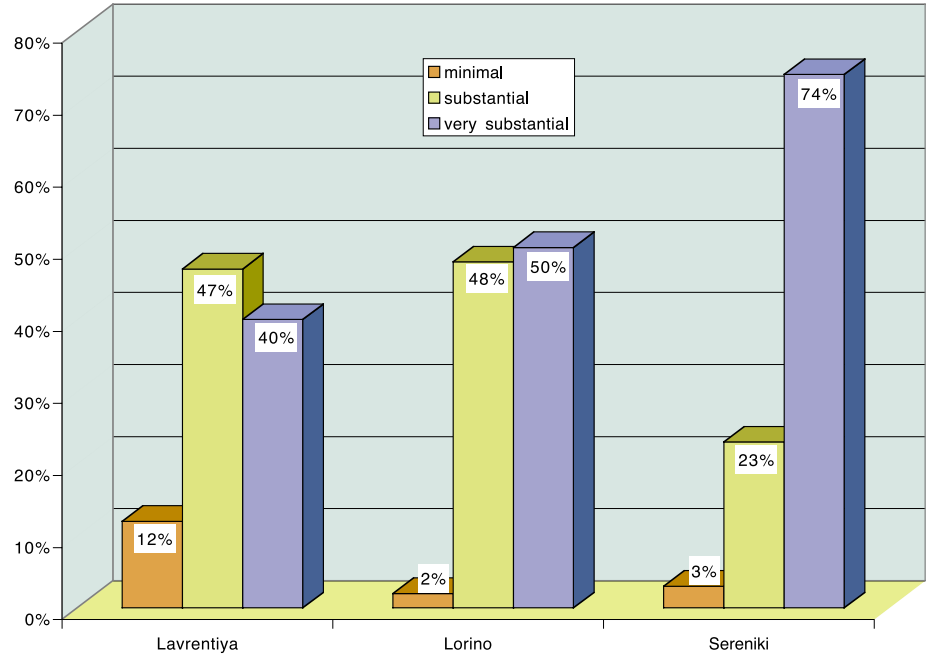


Chart 6. What role has humanitarian aid played in household diets?

indigenous people, when compared to other Alaskans, have very low incomes and a high dependence on unearned income. What would life be like for rural Alaska residents without subsistence resources? From a strictly economic standpoint the harvest of wildlife resources is crucial for the survival of rural Alaska households.

Most rural northwest Alaska communities are accessible only by air, although some commodities such as fuel oil and construction materials are brought in by barge. Bulk items such as food are extremely expensive to transport. For example, if a family of four (with elementary age school children) spends $93.22 for a market basket of food in Anchorage, then this same market basket will cost $217.96 for a similar family in Stebbens. Thus, while Anchorage food costs are about 25% greater than most cities in the western U.S., the rural communities of northwest Alaska have food costs more than twice that of Anchorage.

For the Arctic region (which includes the Bering Strait region), the Alaska Department of Fish and Game (ADF&G) estimates an annual harvest of 10.5 million pounds of wildlife products per year. ADF&G also points out that attaching a dollar value to subsistence uses is difficult, as subsistence products generally do not circulate in markets. However, if families did not have subsistence foods, substitutes would have to be imported and purchased.

If one assumes a replacement expense of $3-5 per pound, the simple replacement costs of the wild food harvests in the Arctic region would be $31.5 million to $52 million.

	Kotzebue	Kivalina	Noatak
Per Capita Income - 1990 Census	$13,906	$4,968	$7,089
Replacement Cost $3/lb.	$1,779	$2,283	$1,383
Replacement Cost $5/lb.	$2,965	$3,805	$2,305

Table 2. Replacement Cost of Subsistence Products at $3 and $5 per pound.

Table 2 puts this into context. With per capita incomes ranging from $5,000 to $14,000, the total replacement cost of wildlife resources in the three communities presented in this comparison range from 13% to 77% of the total income for that community.

It is important to realize that none of the Chukotka communities has the income to replace subsistence resources and that many of the northwest Alaska communities simply could not function if they were required to import all their food. As the analysis indicates, even the relatively affluent (within the region) community of Lavrentiya lacks the financial resources to purchase food to substitute for wildlife resources. And for a community like

Sireniki, which currently spends almost all of its available income on food, the situation would be disastrous. In fact, Sireniki is on the edge of survival and copes by using a substantial amount of humanitarian aid.

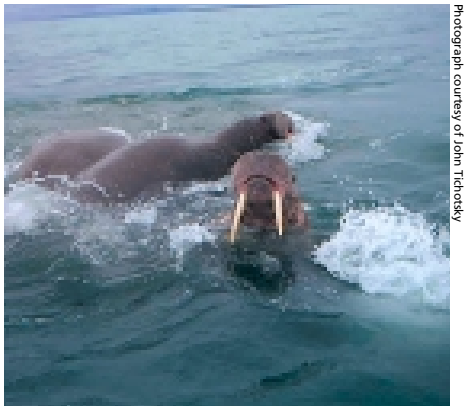
Discussion

One might be concerned that under these trying economic circumstances some resource populations, especially marine mammals, may be exploited beyond the habitat's carrying capacity. A number of factors mitigate this concern.

First, the former state farm system did treat natural resources as commodities, resources to be exploited for their economic return. Marine mammals were hunted factory style by "killer" ships to provide feed for fox farms. Meat and other products designated for human consumption were regulated by market values established by the state. However, the whole structure of this economic system had been dictated by the central government in Moscow and had no real support within the region. In the absence of the centralized "command" economy, the state farm system that supported fox farms and factory ships has disappeared.

Secondly, the commodity view of natural resources is gradually being replaced with a more traditional indigenous orientation. This traditional view emphasizes the reciprocal relationship between hunters and hunted. Traditional values also stress the importance of sharing resources, a non-commercial distribution system *(Callaway n.d.)*. Commercial markets, if there is a profit still to be made, know no constraints. In contrast, traditional values cap the harvest level when a community's needs have been met.* Thus marine mammal hunting with modern technology continues, but the values that these technologies serve have changed.

In addition, the Chukotka Marine Mammal Hunters Association has worked closely with the International Whaling Commission and its technical committees, the North Slope Borough, and the Alaska Eskimo Whaling Commission to identify local nutritional needs and to set sustainable harvest quotas for gray and bowhead whales for the small human populations in the Chukotka region.



Photograph courtesy of John Tichotsky

North Pacific walrus may be at near peak levels, but are rarely harvested for commodity purposes.

In conclusion, it is important to realize that the absence of formal protected areas is not an absence of resource management. Indigenous management regimes are often complex, but one ethic underlies them all — one can not take more animals than one can use, even if an abundance presents itself. The injunction against waste supersedes any other mandate. In the interim, as the Beringia vision unfolds, the resources will be respected.

**Note that marine mammal products such as walrus ivory are still carved in some communities (e.g., Uelen). Traditionally these products were traded but they are now for sale. Demand for these products is limited, however, because the U.S. Marine Mammal Protection Act makes the sale of these Russian products illegal in the U.S. In contrast, indigenous Alaska artists are permitted to sell their carved walrus ivory.*

Acknowledgments

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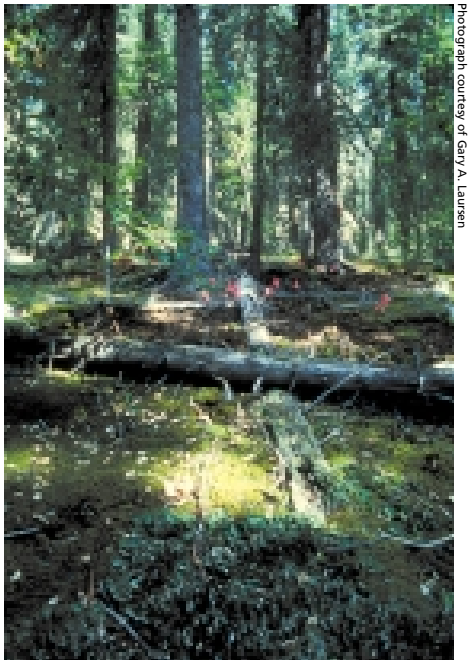
Cycles in the Forest: Mammals, Mushrooms, Mycophagy, Mycoses and Mycorrhizae

by Gary A. Laursen, Dr. Rodney D. Seppelt, and Maggie Hallam



Photograph courtesy of Gary A. Laursen

Figure 1. Interior mixed deciduous/conifer boreal forest stand and small mammal habitat.

Figure 2. Left: Boreal forest landscape mosaic with underlain permafrost.

Photograph courtesy of Gary A. Laursen

Cycles in the Forest

Cyclic interactions are omnipresent in natural ecosystems. In the northern boreal forests like those found in Denali National Park, such interactions involving the smaller microtine and sciurid rodents are vital to the health and survival of the forest ecosystem. These small mycophagous (mushroom eating) mammals consume selected above and below ground mushrooms (gilled agarics, false and true truffles) and distribute the fungal spores through their droppings along prescribed runways. Squirrels utilize spruce trees to dry and preserve these fungi aerially and then make storage caches in old nest sites hollowed out of "witch's brooms," the tangle of small branches and twigs that result from rust fungus infections (mycoses) of tree crowns. Extensive spruce stands could not exist in Alaska's northern boreal forests if it were not for symbiotic mycorrhizal associations with above and below ground fungi that are eaten and dispersed year round by the rodents. Ironically, similar fungi are responsible for the forests' demise and decomposition, which return vital nutrients to the relatively poor soils. (Glossary at end of article with select terms included)

Introduction

Alaska's far northern interior boreal and taiga deciduous broadleaf and conifer forests *(Figure 1)* present a mosaic landscape with discontinuous permafrost *(Figure 2)*. These forested landscapes, such as those seen in Denali National Park and Preserve, support a host of animal, plant, and fungal inhabitants and their associated biological interactions *(Laursen et al. 2001, 2002)*. Forest growth, propagation, regeneration, disease, death, and decomposition are continual processes, and each is important to different components of the total forest cycle.

Both biotic and abiotic factors play a significant role in determining the interaction between components of the ecosystem. Such interactions may have positive or negative influences on the landscape. These complex interactions, or "cycles in the forest," result in the development of complex ecological communities *(Figure 3)*.

Abiotic influences on the forest ecosystem include drying or desiccation, frost, freeze-thaw action, lightning strike, fire, and flood.

Extensive spruce stands could not exist in Alaska's northern boreal forests if it were not for symbiotic mycorrhizal associations with above and below ground fungi that are eaten and dispersed year round by the rodents.

Biotic influences include the building of squirrel and bird dwellings; bark stripping by woodchuck, bear, and porcupine; and browsing by hare and moose. Less obvious biotic influences include the interactions between heart and root rot fungi, broom rusts *(Figure 4)*, and other fungi that cause blights, cankers, casts, crooks, galls, and the "diamond-formations" that are found in some diamond willows. A multitude of insects also invade forest canopies, laying eggs, causing galls and minor lesions, drilling into the damaged stems, and ejecting a form of fecal "sawdust" (frass). Insects forage on young plant parts and carve extensive galleries under the bark where they lay eggs and deposit yeasts and other fungi. These fungi may also subsequently invade host plants, altering

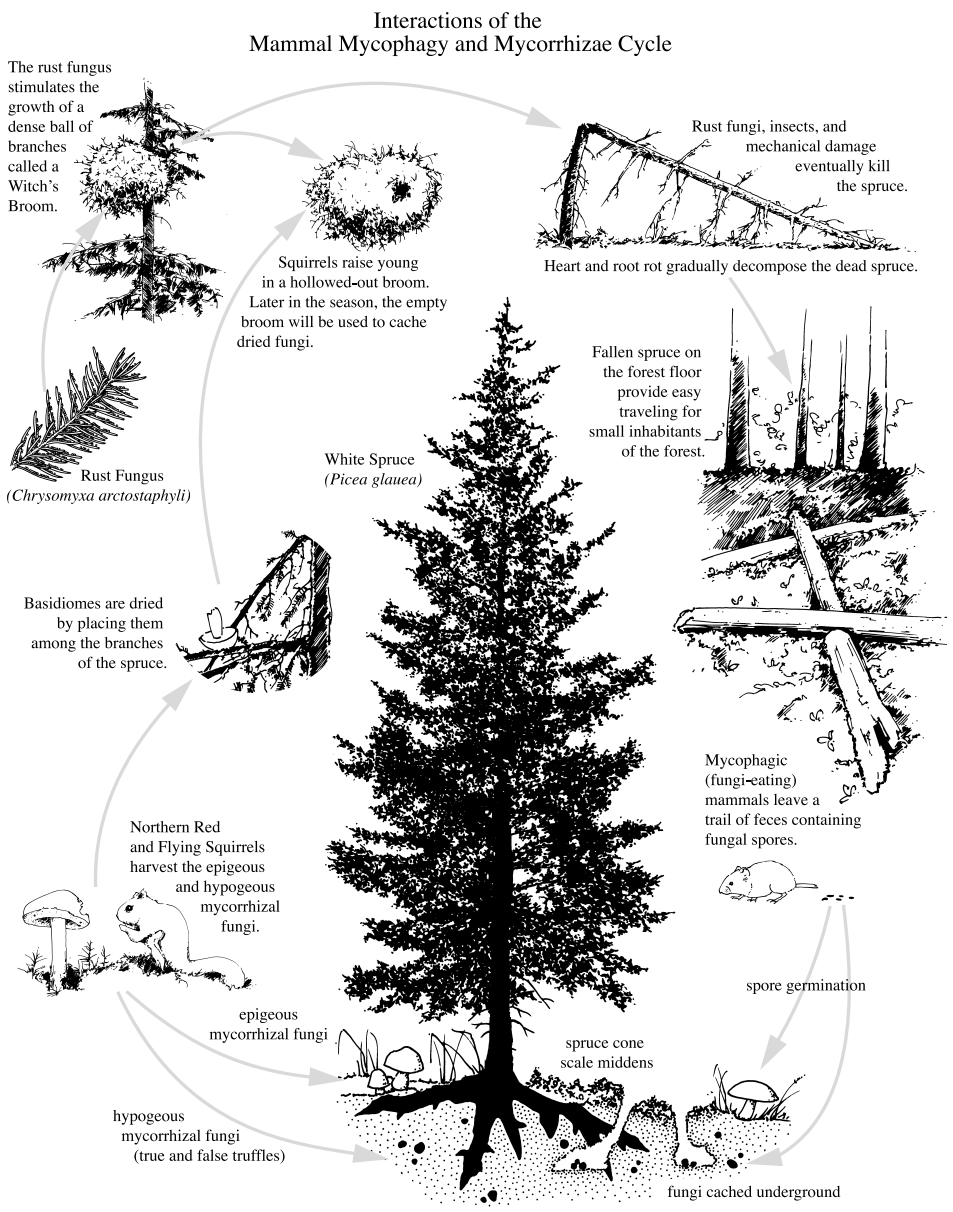


Figure 3. Mammals, mushrooms, mycophagy, mycoses and mycorrhizae boreal forest cycle.

Photograph courtesy of Gary A. Laursen

Squirrels utilize spruce trees to dry and preserve these fungi aerially and then make storage caches in old nest sites hollowed out of "witch's brooms", the tangle of small branches and twigs that result from rust fungus infections (mycoses) of tree crowns.

Figure 4. *Chrysomyxa arctostaphyli* broom rust.

their morphology, inducing disease, and eventually contributing to their slow demise and decomposition. Plant parasites, such as mistletoes, also play a part in influencing these cyclic interactions in the high latitude forests.

Role of Small Mammals in the Forests

At least three mycophagous small mammals—the northern flying squirrel *(Glaucomys sabrinus, Figure 5)*, the red squirrel *(Tamiasciurus hudsonicus, Figure 6)*, and the redback vole *(Clethrionomys rutilus, Figure 7)* play important roles in the dynamic reshaping of arctic woodlands and forests. By their foraging, voles and squirrels, as well as moose and caribou, play vital roles in transporting and transferring microscopic spores of important ectomycorrhizal fungi, without which forests would die.

Importance of Fungi in Forests

In northern high latitude forests, white spruce *(Picea glauca var. albertiana)* and black spruce *(Picea mariana)* are important symbiotic hosts to numerous ascomycete (sac) and basidiomycete (club) fungi, both as above ground (epigeous) and below ground (hypogeous) ectomycorrhizal forms *(Treu et al. 1996)*. The fungal filaments or hyphae *(Figure 8)* have an intimate association with the outside of small roots of trees and greatly assist nutrient uptake into the roots of these host plants. The hyphae coalesce on the outside of the root to form a "mantle" of fungal tissue *(Figure 9)*. This is also true for boreal forest elements of the expansive temperate coastal rain forests of southeast Alaska *(Bruner et al. 2001)*.

Mycorrhizal fungi (myco = fungus; rhiza = root. Literally, root fungi) are essential to the survival of Alaska ecosystems. No tree species would exist in Alaska without this symbiotic or mutually beneficial relationship.

Healthy white spruce live in a mutually beneficial symbiosis with their mycorrhizal fungal partners. The hair-like fungal hyphae or mycelium surround the spruce root tips *(Figure 9)* and invade between cells inside roots *(Figure 10)*. The mycelial filaments are much finer than the roots and root hairs, and greatly increase the surface area available for absorption of nutrients and water

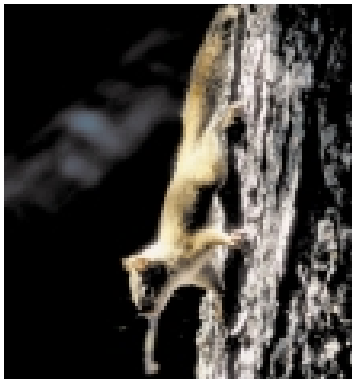
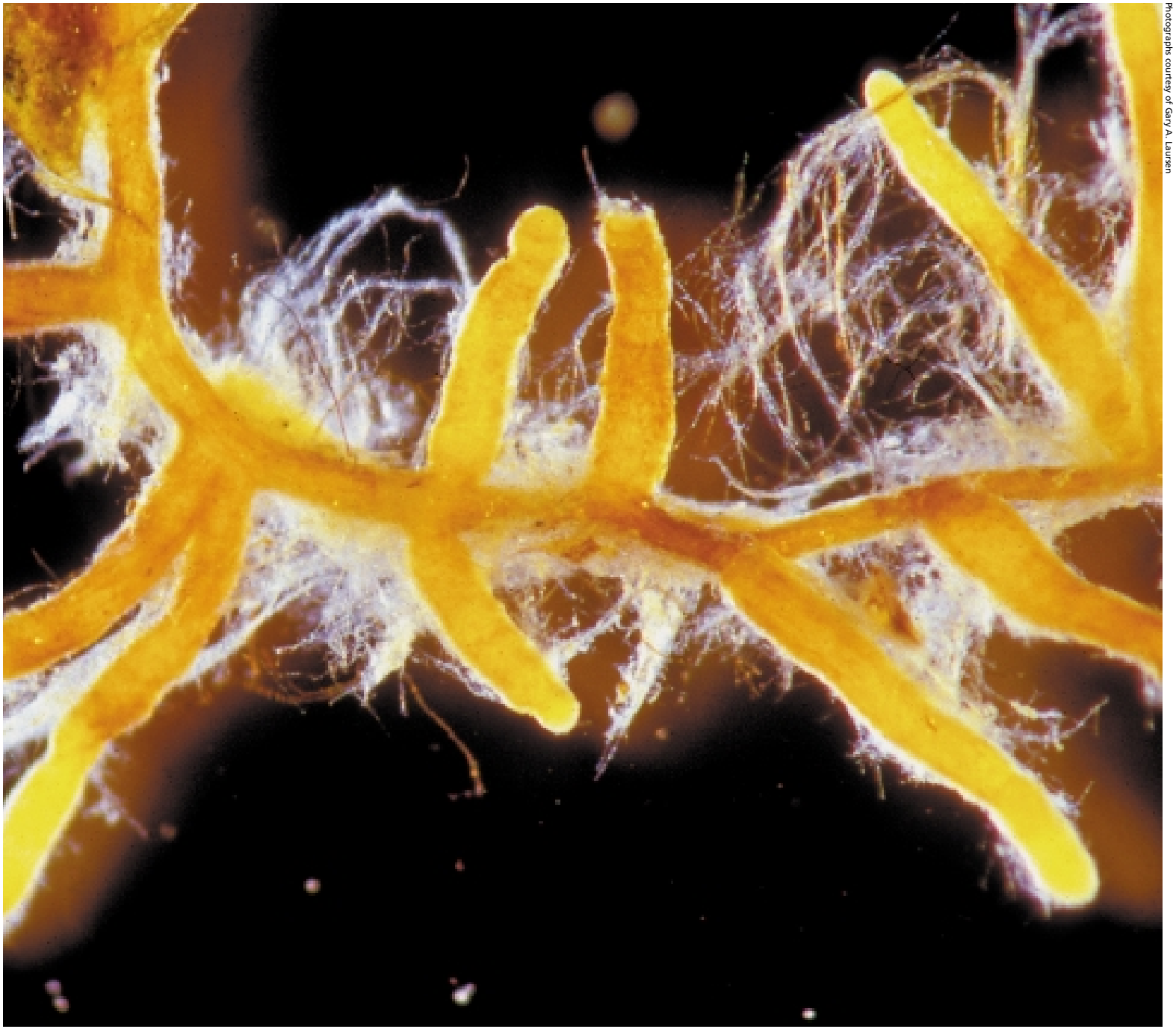


Figure 5. Inset-top: *Glaucomys sabrinus,* the northern flying squirrel eating a truffle fungus.

Figure 6. Inset-middle: *Tamiasciurus hudsonicus,* the northern red squirrel.

Figure 7. Inset-bottom: *Clethrionomys rutilus,* the red-backed vole.

Figure 8. Right: Extended mantel hyphae of an ectomycorrhiza x100



Photographs courtesy of Gary A. Laursen